Project Introduction

The Goddard Image Analysis and Navigation Tool (GIANT) is a tool that was developed for the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) mission to allow GSFC civil servants to perform independent verification and validation of the OSIRIS-REx navigation products. Before the development of GIANT, there were limited Optical Navigation (OpNav) capabilities at Goddard, and they were spread across many tools with many different maintainers. GIANT corrects this by providing a state-of-the-art OpNav tool suite in a single, extensible python package.

GIANT serves as a preprocessing tool that is necessary to include OpNav measurements in orbit determination (OD) software. GIANT ingests OpNav images, performs image processing on the images, and extracts observables from the images which are then passed to an OD tool.

The objective of this IRAD is to enhance GIANT with more advanced capabilities. Specifically, we will add image crossover, scale and rotation cross correlation, limb-based navigation, and weighted attitude/geometric distortion estimation capabilities to the existing GIANT package.

Image crossover measurements refer to the process of identifying the same feature in multiple images. This correspondence can be used to form a strong geometric constraint on the location and orientation of the camera between the images in an orbit determination solution. We will update GIANT to include the ability to generate these crossover measurements through both standard surface feature navigation methods as well as using feature descriptor based methods from the field of computer vision.

The primary workhorse for relative OpNav is cross correlation. In cross correlation, the *a priori* relative position and orientation of the camera with respect to a celestial object is used to generate a predicted image of the object. The predicted image is then correlated with the actual image in order to locate the object in the field of view. This correlation typically only includes translational effects, and does not account for changes in scale (or distance to the object) or rotation. Scale and rotation cross correlation adapts the ideas of translational cross correlation to be able to handle rotation/scale offset. We will add these techniques to GIANT and combine them with the translational correlation techniques to create a more robust correlation routine.

Limb-based OpNav measurements provide a 3 degree of freedom (3DOF) relative position estimate by identifying points along the limb of a tri-axial ellipsoid body in an image, and then using the limb points in combination with a model of the body to generate the position estimate. There are two current state-of-the-art techniques for this type of measurement: limb scanning and ellipse matching. We will implement both limb scanning and ellipse matching techniques in GIANT. We will also investigate extending the ideas of limb-based OpNav to irregular bodies (such as asteroids and comets).

The logo for the Goddard Image Analysis and Navigation Tool (GIANT)

Table of Contents

The current attitude and geometric distortion estimators in GIANT only consider the uncertainty in the measured star locations in an image when performing the estimation. We will re-implement these estimators so they are capable of also handling the uncertainty of the star positions and motions reported by the star catalogues in the estimation. This will allow for an easy method to de-weight stars with poor positional knowledge and keep them from negatively affecting the estimation solutions.

Anticipated Benefits

Optical Navigation is enabling technology for all mission regimes. Upon completion of the proposed improvements, GIANT will be a more robust Optical Navigation tool, and will continue to push the cutting edge of OpNav capabilities. These capabilities will translate to better OpNav measurements, which will allow more precise orbit determination solutions, and subsequently more advanced science campaigns due to the increased precision and accuracy of the orbital knowledge both around major planetary objects (such as moons and planets) and around small bodies (such as asteroids and comets). In addition, the implementation of these routines in GIANT can serve as the first step in preparing them for being implemented as on-board autonomous routines in the future.

Primary U.S. Work Locations and Key Partners
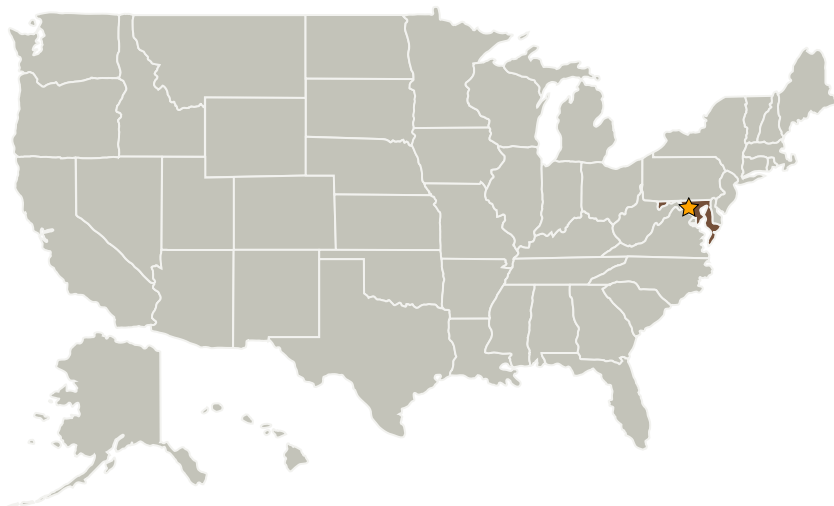
Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Managers:

Jason M Mitchell
Lavida D Cooper
Timothy D Beach

Principal Investigator:

Andrew J Liounis

Co-Investigators:

Cinnamon A Wright
Kenneth M Getzandanner

Organizations Performing Work	Role	Type	Location
⭐Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

Images
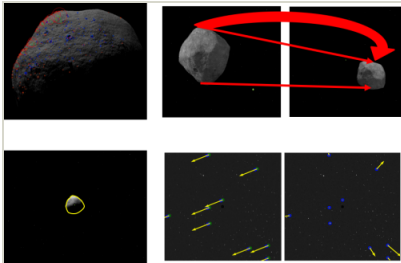
Notional diagrams of the proposed improvements.
Image crossover (top left), scale/rotation invariant correlation (top right), limb based OpNav (lower left) and attitude estimate/geometric camera calibration (lower right) notional diagrams.
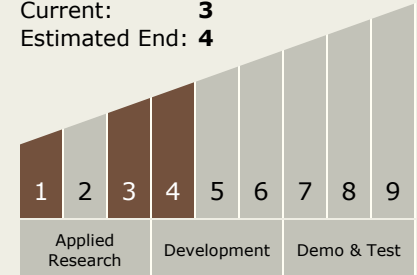*(https://techport.nasa.gov/image/28179)*

The Goddard Image Analysis and Navigation Tool
The logo for the Goddard Image Analysis and Navigation Tool (GIANT)
(https://techport.nasa.gov/image/28178)

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **4**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.2 Navigation Technologies
    └ TX17.2.2 Ground-based Navigation Algorithms

Target Destinations

The Moon, Mars, Others Inside the Solar System

Tech Port

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For more information and an accessible alternative, please visit:
https://techport.nasa.gov/view/93240

Page 3